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(54) Non-A, non-B hepatitis virus genome RNA, cDNA and virus antigen protein.

(57) Non-A, Non-B Hepatitis Virus Genome RNA is disclosed along with cDNA and Virus Antigen Protein.

EP 0 377 303 A1

NON-A, NON-B HEPATITIS VIRUS GENOME RNA, cDNA AND VIRUS ANTIGEN PROTEIN

The present invention relates to Non-A, Non-B hepatitis virus genome RNA, its cDNA as well as its virus antigen protein.

Viral hepatitis is divided approximately into two categories; Enterically transmitted hepatitis and parenterally transmitted (blood-borne) hepatitis. Hepatitis A virus in the former and hepatitis B virus in the latter have been isolated as caustive agents and their virological properties have been elucidated. As the results, diagnosis of and preventive measures against infection with those viruses have been established and the diseases caused by them are held closely under control.

Parenterally transmitted Non-A, Non-B hepatitis (PT-NANB) is said to be about 95% of post-transfusion hepatitis cases in Japan. However, nothing has been confirmed of its causative virus except for its experimental transmission to chimpanzees as the only susceptive animal other than human beings. Almost all attempts made so far by various researchers have failed in identifying the causative agent virus because of the poor reproducibility of the reported results.

Very recently Chiron's scientists reported hepatitis C virus (HCV) as a causative agent of PT-NANB. Its genomic structure is said to resemble that of flavi viruses and an immunoassay using antigenic polypeptide deduced from HCV genomic sequence is, reportedly, capable of detecting antibodies highly associated with PT-NANB. But, virologically there is no evidence that HCV is the PT-NANB agent.

Arima also reported the nucleotide sequences of cDNA clones derived from PT-NANB patients' plasma after Chiron's disclosure of HCV genome. The nucleotide sequences of Chiron's, Arima's and the current invention are mutually independent, i.e., there is no homology among any pair of them.

A Non-A, Non-B hepatitis cDNA clone very closely associated with PT-NANB has been isolated. There is a clear association between the nucleotide sequence of the cDNA clone and PT-NANB; nucleotide-hybridization assays can detect virus and immunoassay using polypeptide deduced from the cDNA can detect antibodies in PT-NANB infected subjects. It has further been found that they are effective in diagnosis, prevention and therapy of PT-NANB as materials for diagnostic test kits or immunogens.

According to one aspect of the present invention there is provided a Non-A, Non-B hepatitis virus genome RNA having the following nucleotide sequence;

5′ U G A U A A A A U A A G C C A G G G U G A
U U C U U A A U U U U C A G U C U G A A G U
C U U U U U U C C C C U C C C A G U C C A G
U C U C C U C A U U U A C U A G G G U C A G
C A G G G A G A G A G A G A A G G U C A G C
U G U G A A U G U U U C C C C U C C C C C A G
A A U G G G G U G G G C U G G U C C U G A G
U U G C A G C U C G G G G U G G G G G A C G
U G A A C C A G C C 3′

(hereinafter called "N-4880-RNA");

According to another aspect of the present invention there is provided a complementary DNA to a non-A, non-B hepatitis virus genome RNA having the following nucleotide sequence;

5′ G G C T G G T T C A C G T C C C C C A C C
C C G A G C T G C A A C T C A G G A C C A G
C C C A C C C C A T T C T G G G G A G G G G
A A A C A T T C A C A G C T G A C C T T C T C
T C T C T C C C T G C T G A C C C T A G T A A
A T G A G G A G A C T G G A C T G G G A G G
G G A A A A A A G A C T T C A G A C T G A A A
A T T A A G A A T C A C C C T G G C T T A T T
T T A T C A 3′

(hereinafter called "N-4880-cDNA-T_3");

According to another aspect of the present invention there is provided a homologous DNA to non-A Non-B hepatitis virus genome RNA having the following nucleotide sequence;

5′ T G A T A A A A T A A G C C A G G G T G A
T T C T T A A T T T T C A G T C T G A A G T C
T T T T T T C C C C T C C C A G T C C A G T C
T C C T C A T T T A C T A G G G T C A G C A G
G G A G A G A G A G A A G G T C A G C T G T
G A A T G T T T C C C C T C C C C A G A A T G
G G G T G G G C T G G T C C T G A G T T G C
A G C T C G G G G G T G G G G G A C G T G A A
C C A G C C 3′

(hereinafter called "N-4880-cDNA-T_7");

According to another aspect of the present invention there is provided a Non-A, Non-B hepatitis virus antigen protein having the following amino acid residue sequence;

Leu - Val - His - Val - Pro -His - Pro - Glu - Leu - Gln -Leu - Arg - Thr - Ser - Pro -Pro - His - Ser - Gly - Glu -Gly - Lys - His - Ser - Gln -Leu - Thr - Phe - Ser - Leu -Ser - Leu - Leu - Thr - Leu -Val - Asn - Glu - Glu - Thr -Gly - Leu - Gly - Gly - Glu -Lys - Arg - Leu - Gln - Thr -Glu - Asn

(hereinafter called "N-4880-P").

The various aspects of the invention will now be described by way of example only, with reference to the following Figures, in which:

Fig.1 is a photograph and shows detection of antibody against PT-NANB associated protein antigen (N-4880-P) by Western blotting,

Fig.2 is a photograph and shows the antibody response of chimpanzee infected with PT-

NANB hepatitis along its time-course by the antibody detection method used for the data in Fig.1; and

Fig.3 is a photograph and shows detection of the virus genome RNA by a hybridization method.

A nucleic acid and antigen protein was produced and refined in the following steps:

(1) Experimental infection of chimpanzees with PT-NANB.

To reproduce PT NANB hepatitis, chimpanzees were intravenously injected with human serum known to have caused post transfusion hepatitis. Since this hepatitis did not show an antigen-antibody response specific to hepatitis A or hepatitis B, it was concluded to be Non-A, Non-B hepatitis. Moreover, because of the ultrastructural changes characteristic to PT-NANB noted in the cytoplasm of hepatocytes, it was diagnosed PT-NANB.

(2) Extraction of nucleic acid from chimpanzee plasma

6ml of chimpanzee plasma which showed PT-NANB virus titre higher than 10^7 CIU/ml was layered on top of 4ml of 20% sucrose and centrifuged on the SW40 rotor (Beckman) centrifuge at 38,000 rpm for 5.4 hours at 4°C. After addition to its precipitate of SDS and Protenase K of 2% and 1mg/ml respectively and, then, overnight incubation at 37°C, nucleic acids extracted with phenol of pH 8.5 was precipitated by ethanol.

(3) cDNA synthesis

The nucleic acid obtained under (2) above was heated at 70°C for 1 minute and had added thereto oligo dT and random hexamer as primers and had further added thereto 4 types of dNTP and reverse transcriptase for reaction to synthesize the primary cDNA chain. Detailed reaction conditions were set according to the protocol provided to the cDNA synthesis kit Amersham (Amersham, England). According to the protocol of the above kit, the seconday cDNA strand was synthesized by ribonuclease H (RNase H) and DNApol.

(4) Phage library of the cDNA

The double stranded cDNA obtained under (3) above was, after treatment with EcoR1 methylase, provided with EcoR1 linker at both ends, ligated with Lamda-gt11 DNA at its EcoR1 site, then, packaged in the phage particles and infected to Ecoli Y1090 to obtain a recombinant phage library of 2 x 10^6 PFU. The protocol of the Lamda-gt 11 cloning kit (Amersham, England) was followed in the experiment.

(5) Screening of phage library.

10,000 PFU of the phage library prepared in (4) above was plated onto the LB agar in 90 x 90mm disc and when plaque was formed, it was covered with the nitrocellulose membrane impregnated with IPTG for incubation for 2 hours at 37°C. After incubation, the membrane was removed, and washed with the buffer solution and blocked for 1 hour at the room temperature with the buffer solution containing 40% foetal calf serum and 0.05% Tween 20. As the primary antibody, 50 times diluted sera of human and chimpanzee known to be PT-NANB virus carriers were used and the membrane was immersed in each serum for overnight incubation at 4°C. After washing with the buffer solution containing 0.05% Tween 20, secondary antibody (peroxidase labelled mixture of antibodies against human IgG, IgM and IgA) was added and incubated for 30 minutes at the room temperature. After washing with the buffer solution containing 0.05% Tween 20, DAB, Ni, Co and H_2O_2 were added for colour reaction.

(6) Prepartion of lysogen.

Antigen positive phage prepared under (5) above were isolated and E. Coli Y1089 was infected with it. The lysogen was prepared according to the method described in "Constructing and screening cDNA Libraries in Lamda gT11", Thanh V. Huynh, et al, DNA Cloning, Volume 1, a practical approach edited by D.M. Clover, P49 - 78, IRL Press, Oxford, 1985.

(7) Purification of B-galactositase fusion protein

Lysate was made from the lysogen prepared under (6) above and was passed through affinity column coated with anti-B-galacsitose antibody and the column was treated with 4.5M $MgCl_2$ to elute purified B-galactosidase fusion protein.

(8) Subcloning and sequencing of cDNA

Phage DNA of antigen positive plaque obtained under (5) above was purified and digested with EcoR1 to take out cDNA and subcloned to the

EcoR1 site of Phagescript™ (STRATAGENE-USA) and sequenced with the Sanger method.

The RNA Probe having homologous sequence to N-4880-CDNA-T_3 hybridized successfully with the virus genome RNA, while the probe having complementary sequence to N-4880-cDNA-T_3 did not. Thus, the genome RNA was concluded to be single stranded and have the same polarity as N-48809-cDNA-T_7.

Since the Open Reading Frame (ORF) starting from the third base and terminating at the stop codon at the 159 - 161th base of N-4880-cDNA-T_3 forms fusion protein with Lac operon of Lamda gt11 phage used for expression of the protein, this ORF was translated to deduce the amino acid sequence of N-4880-P.

The present invention is illustrated by the examples described below which relate to the application of the invention.

(9) Detection of antibody to PT-NANB virus antigen protein (N-4880-P).

After treatment for 5 minutes at 100° C in the presence of 1% SDS and 1% 2ME (2-Mercaptoethanol), B-galactosidase fusion protein obtained under (7) above was subjected to SDS - PAGE (8%) and was transferred to the nitrocellulose membrane (Western blotting). After washing and drying, the membrane was shredded and blocked with 40% foetal calf serum, and those shreds were applied with antibody samples as the primary antibody and incubated overnight at 4° C. After washing with the buffer solution containing the surfactant 0.05% Tween 20, and immersion in biotinylated anti-human IgG or anti-human IgM for 30 minutes incubation at the room temperature, they were applied with the complex of avidin and biotinylated peroxidase, then incubated for 45 minutes at the room temperature. For colour reaction, Konica Immunostain™ (Konica, Japan) or DAB, NI,Co, H_2O_2 method was used. (Fig.1).

Fig.1 shows an example of Western blot analysis of PT-NANB antigen protein (N-4880-P) fused with B-galactosidase.

Primary Antibodies (Test Samples);

a-a′ Chimpanzee plasma before Non-A, Non-B hepatitis infection - (1)
b-b′ Chimpanzee plasma before Non-A, Non-B hepatitis infection - (2)
c-c′ Chimpanzee plasma before Non-A, Non-B hepatitis infection - (3)
d-d′ Chimpanzee plasma with persistent Non-A, Non-B hepatitis infection - (1)
e-e′ Human plasma with persistent Non-A, Non-B infection
f-f′ Chimpanzee plasma with persistent Non-A, Non-B hepatitis infection - (2)
g-g′ Chimpanzee plasma after recovery from Non-A, Non-B hepatitis - (1)
h-h′ Chimpanzee plasma after recovery from Non-A, Non-B hepatitis - (2)
i-i′ Chimpanzee plasma after recovery from Non-A, Non-B hepatitis - (3)
X Anti-B-galactosidase rabbit anti-serum

Secondary Antibodies

a-i anti-human IgM
a′-i′ anti-human IgG
X anti-rabbit Ig

As shown in the Figure 1, highly intensive immuno-stained bands of the fusion protein were noted in lanes d and e′. That is, with persistent Non-A, Non-B infection hosts, antibody against N-4880-P is positive. This suggests that N-4880-P is virus core (gag) protein rather than virus envelope (env) protein.

Second example of the Western blot analysis described in (9) is shown in Fig.2.

Primary Antibodies (Test Samples)

a-t,a′-t′ Same chimpanzee plasma as that used in d-d′ in Fig.1 was taken along its time course of infection with PT-NANB hepatitis and was diluted 20 times.

a : Before infection
b : 4 weeks after infection
c : 5 weeks after infection
d : 6.5 weeks after infection
e : 7 weeks after infection
f : 8 weeks after infection
g : 9 weeks after infection
h : 10 weeks after infection
i : 12 weeks after infection
j : 14 weeks after infection
k : 15.5 weeks after infection
l : 21 weeks after infection
m : 23 weeks after infection
n : 25 weeks after infection
o : 26 weeks after infection
p : 29 weeks after infection
q : 32 weeks after infection
r : 40 weeks after infection
s : 42 weeks after infection
t : 45 weeks after infection
X : Anti-B galactosidase rabbit anti-serum

Secondary Antibodies

(A) Anti-human IgM
(B) Anti-human IgG
X : Anti-rabbit Ig

As shown in the Figure, the antibody against Non-A, Non-B associated antigen protein (N-4880-P) of this invention did not exist in the plasma of the chimpanzee before its infection with PT-NANB hepatitis and was found to appear at approximately 7 weeks after infection.

(10) Hybridization assay using the cDNA as probe Strand specific RNA probes were made by transcribing the recombinant phagescript DNA utilizing T_3 or T_7 promotors which resides at opposite sides of the inserted cDNA.

Fig.3 shows an example of hybridization using radio isotope labelled probe derived from N-4880-cDNA obtained in (10) above. Same plasma as used in the lane d, d′ in Fig.1 was centrifuged in CsCl and fractions with specific gravities 1.22 (1), 1.19 (2), 1.16 (3) and 1.13 (4) were obtained. After dilution of each fraction with the buffer solution, particles of each fraction were precipitated, its nucleic acid was extracted by phenol after digestion with SDS and Protenase K, then, slot blotted on nylon membrane after denaturalization by NaOH (panel A and B), or formaldehyde (panel C and D). As probes for hybridization, RNA probe (A and C) made from Phagescript subclone of N-4880-cDNA by T3 promotor and RNA probe (B and D) made by T7 promotor were used.

As noted in Fig.3, blot 2 of the panel C alone showed high signal. This suggests that the virus genome of Non-A, Non-B hepatitis is single stranded RNA and is complementary to N-4880- cDNA-T_3, and that it is anti-sense strand.

This further suggests that the particle (virus) including the genome RNA has the specific gravity of 1.19g/cm^2 which is proven by the infection experiment with chimpanzees.

Of a type of blood-borne Non-A, Non-B hepatitis, it has been determined that its causitive virus has a specific gravity of 1.19g/cm^2 in cesium chloride density gradient, and that the type of genome RNA is single stranded having (-) polarity. In addition, the partial nucleotide sequence of the genome RNA has been determined as has the nucleotide sequence of its complementary cDNA and antigen protein produced by its translation. RNA, cDNA and protein made available by this invention are useful in the manufacture of PT-NANB hepatitis diagnostic kit, medicine and vaccine.

Further variations and modifications of the foregoing will be apparent to those skilled in the art and are intended to be encompassed by the claims appended hereto.

Claims

1. Non-A, Non-B hepatitis virus genome RNA characterised in that it has the following nucleotide sequence:

5′ U G A U A A A A U A A G C C A G G G U G A
U U C U U A A U U U U C A G U C U G A A G U
C U U U U U U C C C C U C C C C A G U C C A G
U C U C C U C A U U U A C U A G G G U C A G
C A G G G A G A G A G A G A A G G U C A G C
U G U G A A U G U U U C C C C U C C C C C A G
A A U G G G G U G G G C U G G U C C U G A G
U U G C A G C U C G G G G U G G G G G A C G
U G A A C C A G C C 3′

2. Complementary DNA (cDNA), to Non-A, Non-B hepatitis virus genome RNA characterised in that it has the following nucleotide sequence:

5′ G G C T G G T T C A C G T C C C C C A C C
C C G A G C T G C A A C T C A G G A C C A G
C C C A C C C C A T T C T G G G G A G G G G
A A A C A T T C A C A G C T G A C C T T C T C
T C T C T C C C T G C T G A C C C T A G T A A
A T G A G G A G A C T G G A C T G G G A G G
G G A A A A A A G A C T T C A G A C T G A A A
A T T A A G A A T C A C C C T G G C T T A T T
T T A T C A 3′

3. Homologous DNA, to Non-A, Non-B hepatitis virus genome RNA characterised in that it has the following nucleotide sequence:

5′ T G A T A A A A T A A G C C A G G G T G A
T T C T T A A T T T T C A G T C T G A A G T C
T T T T T T C C C C T C C C A G T C C A G T C
T C C T C A T T T A C T A G G G T C A G C A G
G G A G A G A G A G A A G G T C A G C T G T
G A A T G T T T C C C C T C C C C A G A A T G
G G G T G G G C T G G T C C T G A G T T G C
A G C T C G G G G G T G G G G G A C G T G A A
C C A G C C 3′

4. Non-A, Non-B hepatitis virus antigen protein characterised in that it has the following amino acid sequence:

Leu - Val - His - Val - Pro -His - Pro - Glu - Leu - Gln -Leu - Arg - Thr - Ser - Pro -Pro - His - Ser - Gly - Glu -Gly - Lys - His - Ser - Gln -Leu - Thr - Phe - Ser - Leu -Ser - Leu - Leu - Thr - Leu -Val - Asn - Glu - Glu - Thr -Gly - Leu - Gly - Gly - Glu -Lys - Arg - Leu - Gln - Thr -Glu - Asn

5. A Non-A, Non-B hepatitis diagnostic reagent test kit characterised in that it comprises a nucleic acid having the sequence according to claim 2.

6. A Non-A, Non-B hepatitis diagnostic reagent test kit characterised in that it comprises a nucleic acid having the sequence according to claim 3.

7. A Non-A, Non-B hepatitis diagnostic reagent test kit characterised in that it comprises the protein according to claim 4.

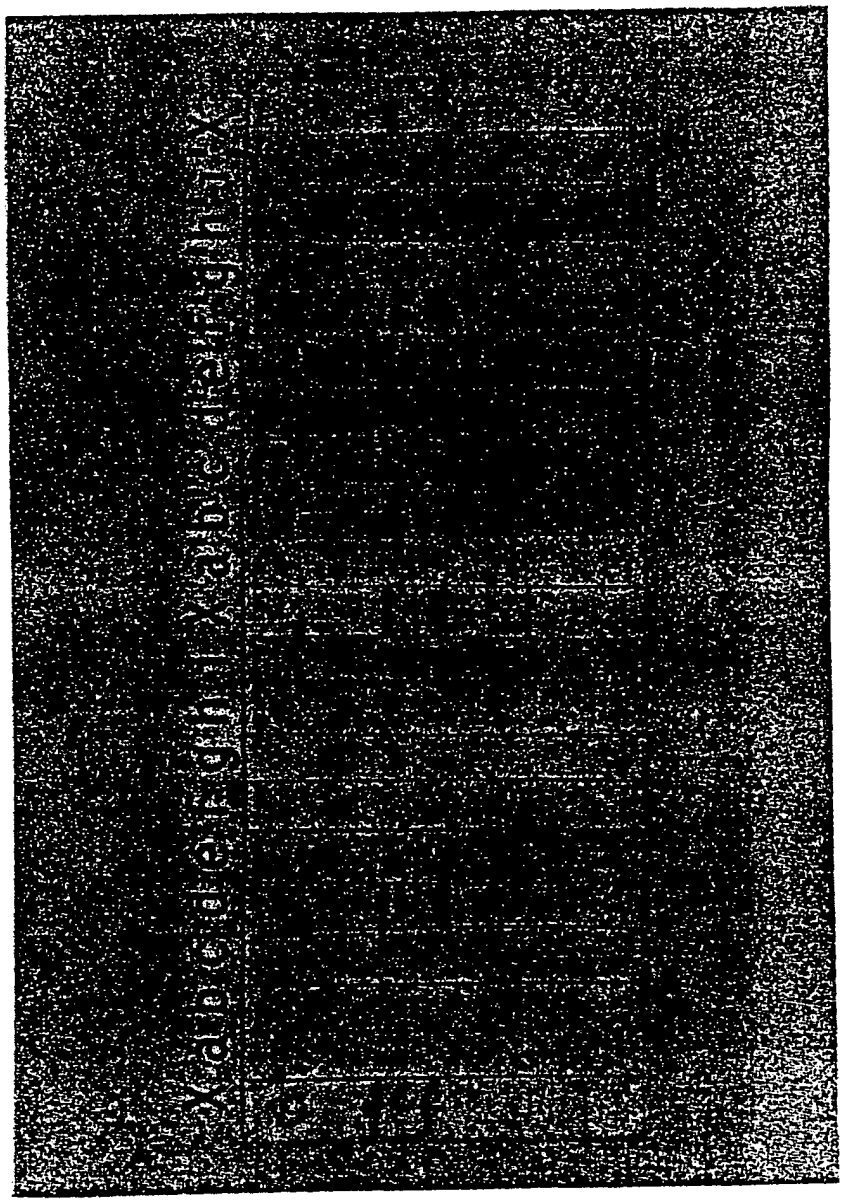

FIG.1

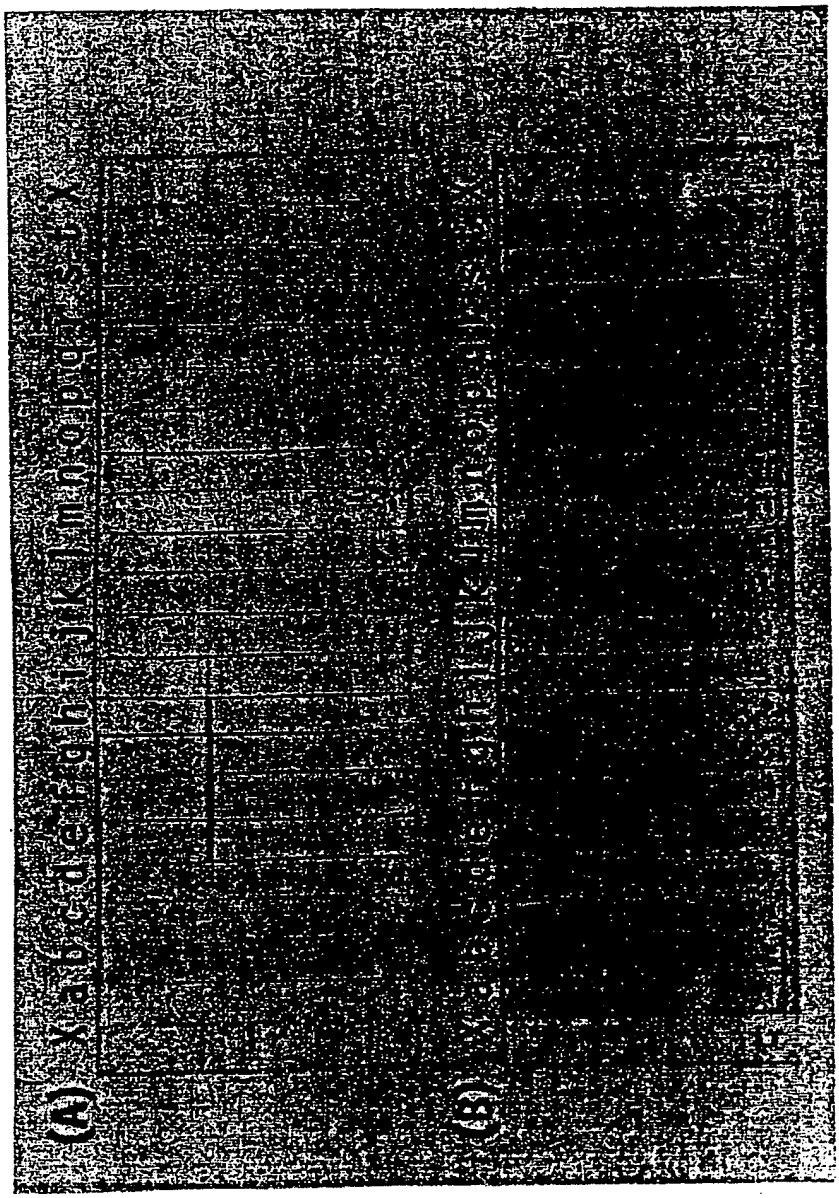

FIG.2

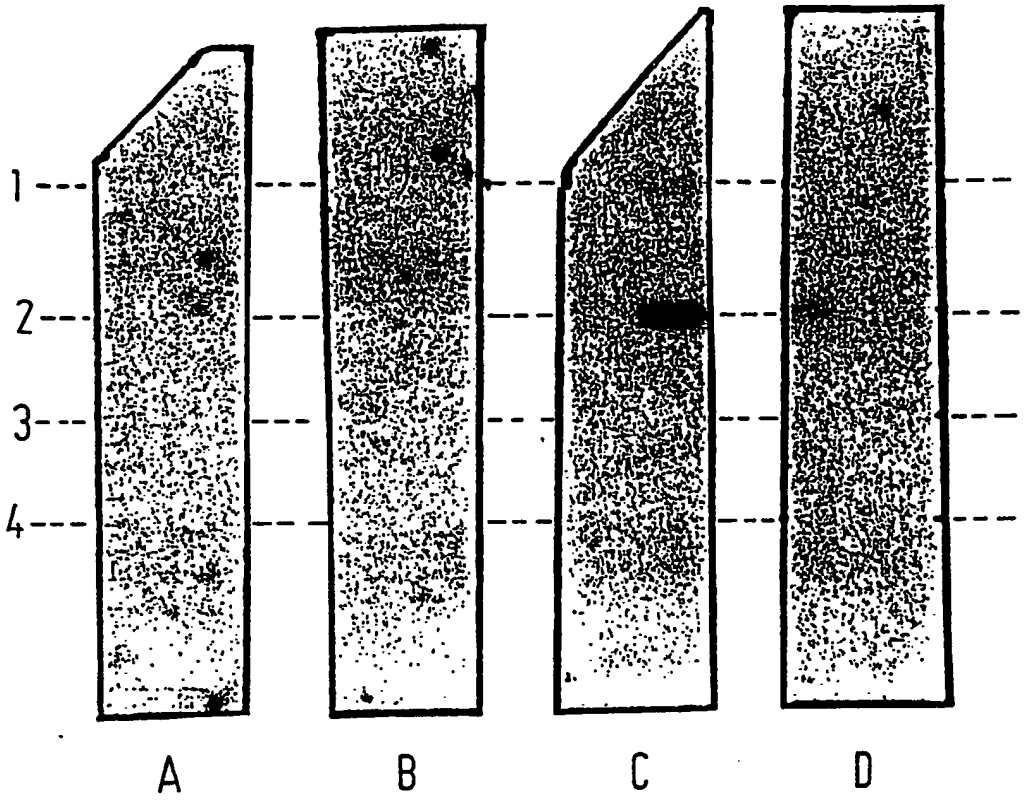

FIG.3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 89 31 3362

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	NATURE, vol. 333, 19th May 1988, page 195; C. EZZELL: "Candidate cause identified of non-A, non-B hepatitis" ---		C 12 N 15/51 A 61 K 39/29 G 01 N 33/576
A	JOURNAL OF VIROLOGICAL METHODS, vol. 10, 1985, pages 307-319, Elsevier Science Publishers B.V. (Biomedical Division); D.W. BRADLEY: "The agents of non-A, non-B viral hepatitis" ---		
P,A	EP-A-0 318 216 (CHIRON CORP.) ---		
P,A	SCIENCE, vol. 244, no. 4902, 21st April 1989, pages 359-362, Washington, DC, US; Q.-L. CHOO et al.: "Isolation of a cDNA clone derived from a blood-borne non-A, non-B viral hepatitis genome" ---		
P,A	SCIENCE, vol. 244, no. 4902, 21st April 1989, pages 362-364, Washington, DC, US; G. KUO et al.: "An assay for circulating antibodies to a major etiologic virus of human non-A, non-B hepatitis" ---		TECHNICAL FIELDS SEARCHED (Int. Cl.5) C 12 N A 61 K G 01 N
P,A	CHEMICAL ABSTRACTS, vol. 112, abstract no. 1980n, Columbus, Ohio, US; T. ARIMA et al.: "Cloning of a cDNA associated with acute and chronic hepatitis C infection generated from patients serum RNA", & GASTROENTEROL. JPN. 1989, 24(5), 540-4 * Abstract * -----		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	11-04-1990	SKELLY J.M.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document.

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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5′ U G A U A A A A U A A G C C A G G G

U G A U U C U U A A U U U U C A G U C U

G A A G U C U U U U U U C C C C U C C C

A G U C C A G U C U C C U C A U U U A C

U A G G G U C A G C A G G G A G A G A G

A G A A G G U C A G C U G U G A A U G U

U U C C C C U C C C C A G A A U G G G G

U G G G C U G G U C C U G A G U U G C A

G C U C G G G G U G G G G G A C G U G A

A C C A G C C 3′

(hereinafter called "N-4880-RNA");

According to another aspect of the present invention there is provided a complementary DNA to a non-A, non-B hepatitis virus genome RNA having the following nucleotide sequence;

5′ G G C T G G T T C A C G T C C C C C

A C C C C G A G C T G C A A C T C A G G

A C C A G C C C A C C C C A T T C T G G

G G A G G G G A A A C A T T C A C A G C

T G A C C T T C T C T C T C T C C C C T G

C T G A C C C T A G T A A A T G A G G A

G A C T G G A C T G G G A G G G G A A A

A A A G A C T T C A G A C T G A A A A T

T A A G A A T C A C C C T G G C T T A T

T T T A T C A 3′

(hereinafter called "N-4880-cDNA-T_3");

According to another aspect of the present invention there is provided a homologous DNA to non-A Non-B hepatitis virus genome RNA having the following nucleotide sequence;

5′ T G A T A A A A T A A G C C A G G G

T G A T T C T T A A T T T T C A G T C T

G A A G T C T T T T T T C C C C T C C C

A G T C C A G T C T C C T C A T T T A C

T A G G G T C A G C A G G G A G A G A G

A G A A G G T C A G C T G T G A A T G T

T T C C C C T C C C C A G A A T G G G G

T G G G C T G G T C C T G A G T T G C A

G C T C G G G G T G G G G G A C G T G A

A C C A G C C 3′

(hereinafter called "N-4880-cDNA-T_7");

According to another aspect of the present invention there is provided a Non-A, Non-B hepatitis virus antigen protein having the following amino acid residue sequence;

Leu - Val - His - Val - Pro

-His - Pro - Glu - Leu - Gln

-Leu - Arg - Thr - Ser - Pro

-Pro - His - Ser - Gly - Glu

-Gly - Lys - His - Ser - Gln

-Leu - Thr - Phe - Ser - Leu

-Ser - Leu - Leu - Thr - Leu

-Val - Asn - Glu - Glu - Thr

-Gly - Leu - Gly - Gly - Glu

-Lys - Arg - Leu - Gln - Thr

-Glu - Asn

(hereinafter called "N-4880-P").

The various aspects of the invention will now be described by way of example only, with reference to the following Figures, in which:

Fig.1 is a photograph and shows detection of antibody against PT-NANB associated protein antigen (N-4880-P) by Western blotting,

Fig.2 is a photograph and shows the antibody response of chimpanzee infected with PT-NANB hepatitis along its time-course by the antibody detection method used for the data in Fig.1; and

Fig.3 is a photograph and shows detection of the virus genome RNA by a hybridization method.

A nucleic acid and antigen protein was produced and refined in the following steps:

(1) Experimental infection of chimpanzees with PT-NANB.

To reproduce PT NANB hepatitis, chimpanzees were intravenously injected with human serum known to have caused post transfusion hepatitis. Since this hepatitis did not show an antigen-antibody response specific to hepatitis A or hepatitis B, it was concluded to be Non-A, Non-B hepatitis. Moreover, because of the ultra-structural changes characteristic to PT-NANB noted in the cytoplasm of hepatocytes, it was diagnosed PT-NANB.

(2) Extraction of nucleic acid from chimpanzee plasma

6ml of chimpanzee plasma which showed PT-NANB virus titre higher than 10^7 CIU/ml was layered on top of 4ml of 20% sucrose and centrifuged on the SW40 rotor (Beckman) centrifuge at 38,000 rpm for 5.4 hours at 4°C. After addition to its precipitate of SDS and Protenase K of 2% and 1mg/ml respectively and, then, over-night incubation at 37°C, nucleic acids extracted with phenol of pH 8.5 was precipitated by ethanol.

(3) cDNA synthesis

The nucleic acid obtained under (2) above was heated at 70°C for 1 minute and had added thereto oligo dT and random hexamer as primers and had further added thereto 4 types of dNTP and reverse transcriptase for reaction to synthesize the primary cDNA chain. Detailed reaction conditions were set according to the protocol provided to the cDNA synthesis kit Amersham (Amersham, England). According to the protocol of the above kit, the seconday cDNA strand was synthesized by ribonuclease H (RNase H) and DNApol.

(4) Phage library of the cDNA

The double stranded cDNA obtained under (3) above was, after treatment with EcoR1 methylase, provided with EcoR1 linker at both ends, ligated with Lamda-gt11 DNA at its EcoR1 site, then, packaged in the phage particles and infected to Ecoli Y1090 to obtain a recombinant phage library of 2×10^6 PFU. The protocol of the Lamda-gt 11 cloning kit (Amersham, England) was followed in the experiment.

(5) Screening of phage library.

10,000 PFU of the phage library prepared in (4) above was plated onto the LB agar in 90 x 90mm disc and when plaque was formed, it was covered with the nitrocellulose membrane impregnated with IPTG for incubation for 2 hours at 37°C. After incubation, the membrane was removed, and washed with the buffer solution and blocked for 1 hour at the room temperature with the buffer solution containing 40% foetal calf serum and 0.05% Tween 20. As the primary antibody, 50 times diluted sera of human and chimpanzee known to be PT-NANB virus carriers were used and the membrane was immersed in each serum for overnight incubation at 4°C. After washing with the buffer solution containing 0.05% Tween 20, secondary antibody (peroxidase labelled mixture of antibodies against human IgG, IgM and IgA) was added and incubated for 30 minutes at the room temperature. After washing with the buffer solution containing 0.05% Tween 20, DAB, Ni, Co and H_2O_2 were added for colour reaction.

(6) Prepartion of lysogen.

Antigen positive phage prepared under (5) above were isolated and E. Coli Y1089 was infected with it. The lysogen was prepared according to the method described in "Constructing and screening cDNA Libraries in Lamda gT11", Thanh V, Huynh, et al, DNA Cloning, Volume 1, a practical approach edited by D.M. Clover, P49 - 78, IRL Press, Oxford, 1985.

(7) Purification of B-galactositase fusion protein

Lysate was made from the lysogen prepared under (6) above and was passed through affinity column coated with anti-B-galacsitose antibody and the column was treated with 4.5M $MgCl_2$ to elute purified B-galactosidase fusion protein.

(8) Subcloning and sequencing of cDNA

Phage DNA of antigen positive plaque obtained under (5) above was purified and digested with EcoR1 to take out cDNA and subcloned to the EcoR1 site of Phagescript™ (STRATAGENE-USA) and sequenced with the Sanger method.

The RNA Probe having homologous sequence to N-4880-CDNA-T_3 hybridized successfully with the virus genome RNA, while the probe having complementary sequence to N-4880-cDNA-T_3 did not. Thus, the genome RNA was concluded to be single stranded and have the same polarity as N-48809-cDNA-T_7.

Since the Open Reading Frame (ORF) starting from the third base and terminating at the stop codon at the 159 - 161th base of N-4880-cDNA-T_3 forms fusion protein with Lac operon of Lamda gt11 phage used for expression of the protein, this ORF was translated to deduce the amino acid sequence of N-4880-P.

The present invention is illustrated by the examples described below which relate to the application of the invention.

(9) Detection of antibody to PT-NANB virus antigen protein (N-4880-P).

After treatment for 5 minutes at 100°C in the presence of 1% SDS and 1% 2ME (2-Mercaptoethanol), B-galactosidase fusion protein obtained under (7) above was subjected to SDS - PAGE (8%) and was transferred to the nitrocellulose membrane (Western blotting). After washing and drying, the membrane was shredded and blocked with 40% foetal calf serum, and those shreds were applied with antibody samples as the primary antibody and incubated overnight at 4°C. After washing with the buffer solution containing the surfactant 0.05% Tween 20, and immersion in biotinylated anti-human IgG or anti-human IgM for 30 minutes incubation at the room temperature, they were applied with the complex of avidin and biotinylated peroxidase, then incubated for 45 minutes at the room temperature. For colour reaction, Konica Immunostain™ (Konica, Japan) or DAB, Ni,Co, H_2O_2 method was used. (Fig.1).

Fig.1 shows an example of Western blot analysis of PT-NANB antigen protein (N-4880-P) fused with B-galactosidase.

Primary Antibodies (Test Samples);

a-a' Chimpanzee plasma before Non-A, Non-B hepatitis infection - (1)
b-b' Chimpanzee plasma before Non-A, Non-B hepatitis infection - (2)
c-c' Chimpanzee plasma before Non-A, Non-B hepatitis infection - (3)
d-d' Chimpanzee plasma with persistent Non-A, Non-B hepatitis infection - (1)
e-e' Human plasma with persistent Non-A, Non-B infection
f-f' Chimpanzee plasma with persistent Non-A, Non-B hepatitis infection - (2)
g-g' Chimpanzee plasma after recovery from Non-A, Non-B hepatitis - (1)
h-h' Chimpanzee plasma after recovery from Non-A, Non-B hepatitis - (2)
i-i' Chimpanzee plasma after recovery from Non-A, Non-B hepatitis - (3)
X Anti-B-galactosidase rabbit anti-serum

Secondary Antibodies

a-i anti-human IgM
a'-i' anti-human IgG
X anti-rabbit Ig

As shown in the Figure 1, highly intensive immuno-stained bands of the fusion protein were noted in lanes d and e'. That is, with persistent Non-A, Non-B infection hosts, antibody against N-4880-P is positive. This suggests that N-4880-P is virus core (gag) protein rather than virus envelope (env) protein.

Second example of the Western blot analysis described in (9) is shown in Fig.2.

Primary Antibodies (Test Samples)

a-t,a'-t' Same chimpanzee plasma as that used in d-d' in Fig.1 was taken along its time course of infection with PT-NANB hepatitis and was diluted 20 times.

a : Before infection
b : 4 weeks after infection
c : 5 weeks after infection
d : 6.5 weeks after infection
e : 7 weeks after infection
f : 8 weeks after infection
g : 9 weeks after infection
h : 10 weeks after infection
i : 12 weeks after infection
j : 14 weeks after infection
k : 15.5 weeks after infection
l : 21 weeks after infection
m : 23 weeks after infection
n : 25 weeks after infection
o : 26 weeks after infection
p : 29 weeks after infection
q : 32 weeks after infection
r : 40 weeks after infection
s : 42 weeks after infection
t : 45 weeks after infection
X : Anti-B galactosidase rabbit anti-serum

Secondary Antibodies

(A) Anti-human IgM
(B) Anti-human IgG
X: Anti-rabbit Ig

As shown in the Figure, the antibody against Non-A, Non-B associated antigen protein (N-4880-P) of this

invention did not exist in the plasma of the chimpanzee before its infection with PT-NANB hepatitis and was found to appear at approximately 7 weeks after infection.

(10) Hybridization assay using the cDNA as probe Strand specific RNA probes were made by transcribing the recombinant phagescript DNA utilizing T_3 or T_7 promotors which resides at opposite sides of the inserted cDNA.

Fig.3 shows an example of hybridization using radio isotope labelled probe derived from N-4880-cDNA obtained in (10) above. Same plasma as used in the lane d, d' in Fig.1 was centrifuged in CsCl and fractions with specific gravities 1.22 (1), 1.19 (2), 1.16 (3) and 1.13 (4) were obtained. After dilution of each fraction with the buffer solution, particles of each fraction were precipitated, its nucleic acid was extracted by phenol after digestion with SDS and Protenase K, then, slot blotted on nylon membrane after denaturalization by NaOH (panel A and B), or formaldehyde (panel C and D). As probes for hybridization, RNA probe (A and C) made from Phagescript subclone of N-4880-cDNA by T3 promotor and RNA probe (B and D) made by T7 promotor were used.

As noted in Fig.3, blot 2 of the panel C alone showed high signal. This suggests that the virus genome of Non-A, Non-B hepatitis is single stranded RNA and is complementary to N-4880- cDNA-T_3, and that it is antisense strand.

This further suggests that the particle (virus) including the genome RNA has the specific gravity of 1.19g/cm^2 which is proven by the infection experiment with chimpanzees.

Of a type of blood-borne Non-A, Non-B hepatitis, it has been determined that its causitive virus has a specific gravity of 1.19g/cm^2 in cesium chloride density gradient, and that the type of genome RNA is single stranded having (-) polarity. In addition, the partial nucleotide sequence of the genome RNA has been determined as has the nucleotide sequence of its complementary cDNA and antigen protein produced by its translation. RNA, cDNA and protein made available by this invention are useful in the manufacture of PT-NANB hepatitis diagnostic kit, medicine and vaccine.

Further variations and modifications of the foregoing will be apparent to those skilled in the art and are intended to be encompassed by the claims appended hereto.

Claims

1. Non-A, Non-B hepatitis virus genome RNA characterised in that it has the following nucleotide sequence:

5′ U G A U A A A A U A A G C C A G G G

U G A U U C U U A A U U U U C A G U C U

G A A G U C U U U U U U C C C C U C C C

A G U C C A G U C U C C U C A U U U A C

U A G G G U C A G C A G G G A G A G A G

A G A A G G U C A G C U G U G A A U G U

U U C C C C U C C C C C A G A A U G G G G

U G G G C U G G G U C C U G A G U U G C A

G C U C G G G G G U G G G G G A C G U G A

A C C A G C C 3′

2. Complementary DNA (cDNA), to Non-A, Non-B hepatitis virus genome RNA characterised in that it has the following nucleotide sequence:

5′ G G C T G G T T C A C G T C C C C C

A C C C C G A G C T G C A A C T C A G G

A C C A G C C C A C C C C A T T C T G G

G G A G G G G A A A C A T T C A C A G C

T G A C C T T C T C T C T C T C C C T G

C T G A C C C T A G T A A A T G A G G A

G A C T G G A C T G G G A G G G G A A A

A A A G A C T T C A G A C T G A A A A T

T A A G A A T C A C C C T G G C T T A T

T T T A T C A 3′

3. Homologous DNA, to Non-A, Non-B hepatitis virus genome RNA characterised in that it has the following nucleotide sequence:

5′ T G A T A A A A T A A G C C A G G G

T G A T T C T T A A T T T T C A G T C T

G A A G T C T T T T T T C C C C T C C C

A G T C C A G T C T C C T C A T T T A C

T A G G G T C A G C A G G G A G A G A G

A G A A G G T C A G C T G T G A A T G T

T T C C C C T C C C C A G A A T G G G G

T G G G C T G G T C C T G A G T T G C A

G C T C G G G G T G G G G G A C G T G A

A C C A G C C 3′

4. Non-A, Non-B hepatitis virus antigen protein characterised in that it has the following amino acid sequence:

Leu - Val - His - Val - Pro

-His - Pro - Glu - Leu - Gln

-Leu - Arg - Thr - Ser - Pro

-Pro - His - Ser - Gly - Glu

-Gly - Lys - His - Ser - Gln

-Leu - Thr - Phe - Ser - Leu

-Ser - Leu - Leu - Thr - Leu

-Val - Asn - Glu - Glu - Thr

-Gly - Leu - Gly - Gly - Glu

-Lys - Arg - Leu - Gln - Thr

-Glu - Asn

5. A Non-A, Non-B hepatitis diagnostic reagent test kit characterised in that it comprises a nucleic acid having the sequence according to claim 2.

6. A Non-A, Non-B hepatitis diagnostic reagent test kit characterised in that it comprises a nucleic acid having the sequence according to claim 3.

7. A Non-A, Non-B hepatitis diagnostic reagent test kit characterised in that it comprises the protein according to claim 4.

Patentansprüche

1. Genom-RNA von Non-A, Non-B Hepatitisvirus gekennzeichnet durch folgende Nukleotidsequenz:

5′ U G A U A A A A U A A G C C A G G G

U G A U U C U U A A U U U U C A G U C U

G A A G U C U U U U U U C C C C U C C C

A G U C C A G U C U C C U C A U U U A C

U A G G G U C A G C A G G G A G A G A G

A G A A G G U C A C C U G U G A A U G U

U U C C C C U C C C C A G A A U G G G G

U G G G C U G G U C C U G A G U U G C A

G C U C G G G G U G G G G G A C G U G A

A C C A G C C 3′

2. Non-A, Non-B Hepatitisnirusgenom -RNA komplementäre DNA (cDNA), gekennzeichnet durch folgende Nukleotidsequenz:

5' G G C T G G T T C A C G T C C C C C
A C C C C G A G C T G C A A C T C A G G
A C C A G C C C A C C C C A T T C T G G
G G A G G G G A A A C A T T C A C A G C
T G A C C T T C T C T C T C T C C C T G
C T G A C C C T A G T A A A T G A G G A
G A C T G G A C T G G G A G G G G A A A
A A A G A C T T C A G A C T G A A A A T
T A A G A A T C A C C C T G G C T T A T
T T T A T C A 3'

3. Non-A, Non-B Hepatitisuirusgenom -RNA homologe DNA, gekennzeichnet durch folgende Nukleotidsequenz:

5' T G A T A A A A T A A G C C A G G G
T G A T T C T T A A T T T T C A G T C T
G A A G T C T T T T T T C C C C T C C C
A G T C C A G T C T C C T C A T T T A C
T A G G G T C A G C A G G G A G A G A G
A G A A G G T C A G C T G T G A A T G T
T T C C C C T C C C C A G A A T G G G G
T G G G C T G G T C C T G A G T T G C A
G C T C G G G G G T G G G G G A C G T G A
A C C A G C C 3'

4. Antigenes Protein von Non-A, Non-B Hepatitisvirus gekennzeichnet durch folgende Aminosäuresequenz:

Leu - Val - His - Val - Pro
-His - Pro - Glu - Leu - Gln
-Leu - Arg - Thr - Ser - Pro
-Pro - His - Ser - Gly - Glu
-Gly - Lys - His - Ser - Gln
-Leu - Thr - Phe - Ser - Leu
-Ser - Leu - Leu - Thr - Leu
-Val - Asn - Glu - Glu - Thr
-Gly - Leu - Gly - Gly - Glu
-Lys - Arg - Leu - Gln - Thr
-Glu - Asn

5. Reagens-Test Kit zur Diagnose der Non-A. Non-B Hepatitis, dadurch gekennzeichnet, daß er Nukleinsäure mit gleicher Sequenz wie in Patentanspruch 2 enthält.

6. Reagens-Test-Kit zur Diagnose der Non-A, Non-B Hepatitis, dadurch gekennzeithnet, daß er Nukleinsäure mit gleicher Sequenz wie in Patentanspruch 3 enthält.

7. Reagens-Test-Kit zur Diagnose der Non-A, Non-B Hepatitis, dadurch gekennzeichnet, daß er das gleiche Protein wie in Patentanspruch 4 enthält.

Revendications

1. ARN du génome du virus de l'hépatite non-A non-B, caractérisé en ce qu'il présente la séquence suivante de nucléotides:

5' U G A U A A A A U A A G C C A G G G
U G A U U C U U A A U U U U C A G U C U
G A A G U C U U U U U U U C C C C U C C C
A G U C C A G U C U C C U C A U U U A C
U A G G G U C A G C A G G G A G A G A G
A G A A G G U C A G C U G U G A A U G U
U U C C C C U C C C C C A G A A U G G G G
U G G G G C U G G U C C U G A G U U G C A
G C U C G G G G U G G G G G A C G U G A
A C C A G C C 3'

2. ADN complémentaire (ADNc) correspondant à l'ARN du génome du virus de l'hépatite non-A non-B, caractérisé en ce qu'il présente la séquence suivante de nucléotides:

5' G G C T G G T T C A C G T C C C C C

A C C C C G A G C T G C A A C T C A G G

A C C A G C C C A C C C C A T T C T G G

G G A G G G G A A A C A T T C A C A G C

T G A C C T T C T C T C T C T C C C C T G

C T G A C C C T A G T A A A T G A G G A

G A C T G G A C T G G G A G G G G A A A

A A A G A C T T C A G A C T G A A A A T

T A A G A A T C A C C C T G G C T T A T

T T T A T C A 3'

3. ADN homologue correspondant à l'ARN du génome du virus de l'hépatite non-A non-B, caractérisé en ce qu'il présente la séquence suivante de nucléotides:

5' T G A T A A A A T A A G C C A G G G

T G A T T C T T A A T T T T C A G T C T

G A A G T C T T T T T T T C C C C T C C C

A G T C C A G T C T C C T C A T T T A C

T A G G G T C A G C A G G G A G A G A G

A G A A G G T C A G C T G T G A A T G T

T T C C C C T C C C C A G A A T G G G G

T G G G C T G G T C C T G A G T T G C A

G C T C G G G G T G G G G G A C G T G A

A C C A G C C 3'

4. Protéine antigène du virus de l'hépatite non-A non-B, caractérisée en ce qu'elle présente la séquence suivante d'acides aminés :

Leu - Val - His - Val - Pro

-His - Pro - Glu - Leu - Gln

-Leu - Arg - Thr - Ser - Pro

-Pro - His - Ser - Gly - Glu

-Gly - Lys - His - Ser - Gln

-Leu - Thr - Phe - Ser - Leu

-Ser - Leu - Leu - Thr - Leu

-Val - Asn - Glu - Glu - Thr

-Gly - Leu - Gly - Gly - Glu

-Lys - Arg - Leu - Gln - Thr

-Glu - Asn

5. Trousse de réactifs pour diagnostic de l'hépatite non-A non-B, caractérisée en ce qu'elle comporte un acide nucléique présentant la séquence indiquée dans la revendication 2.

6. Trousse de réactifs pour diagnostic de l'hépatite non-A non-B, caractérisée en ce qu'elle comporte un acide nucléique présentant la séquence indiquée dans la revendication 3.

7. Trousse de réactifs pour diagnostic de l'hépatite non-A non-B, caractérisée en ce qu'elle comporte la protéine présentant la séquence indiquée dans la revendication 4.

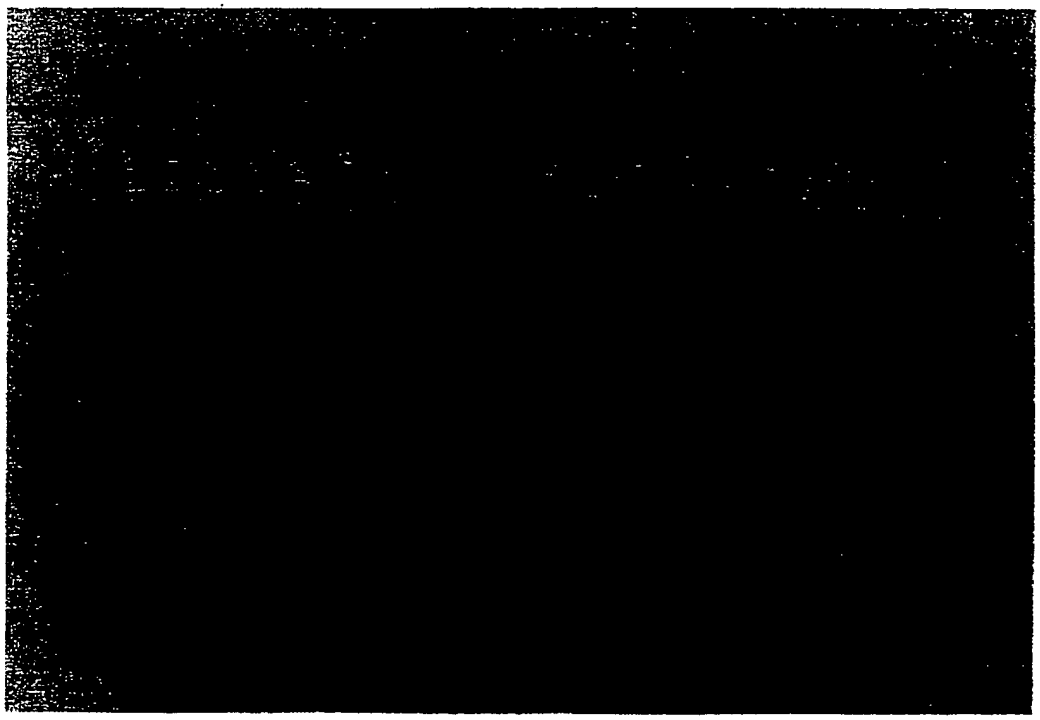

FIG.1

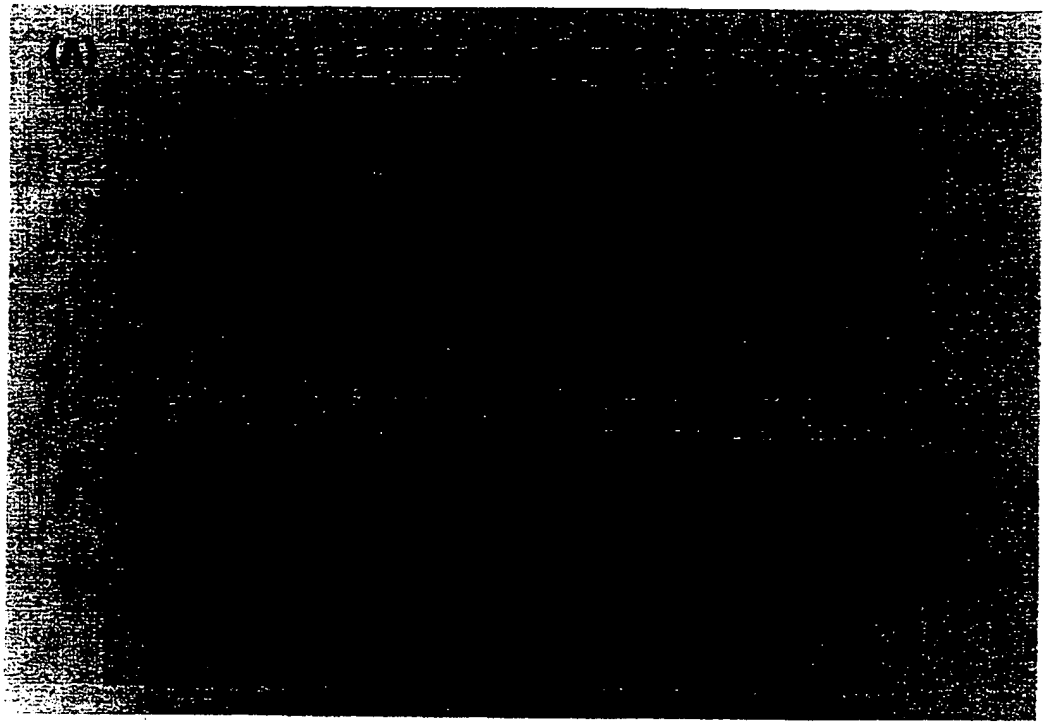

FIG2

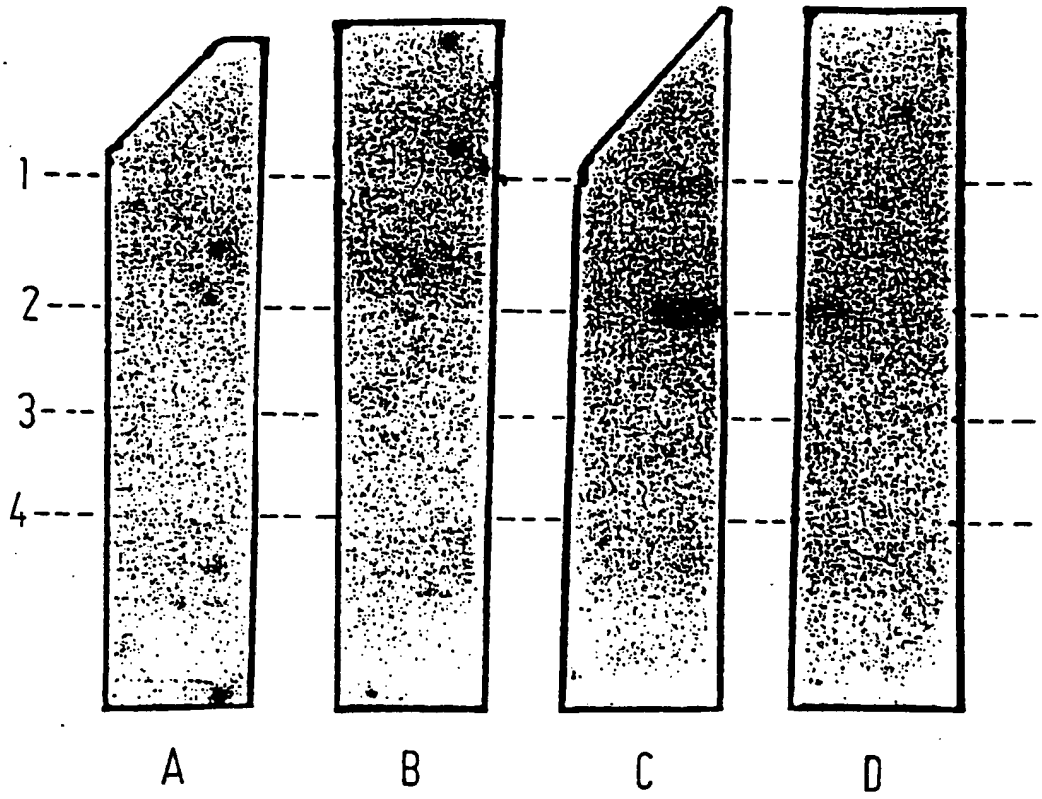

FIG.3